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TOWARDS FULLY AUTOMATED PSYCHOTHERAPY FOR ADULTS

BAS - Behavioral Activation Scheduling via web and mobile phone

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Abstract: Behavioural activation treatment has been found to be an effective psychological treatment for depression, also if delivered as self-administered psychotherapy via the internet. However, the role of supporting professionals remains important for successful application of the therapy. In this paper a system is presented that delivers automated behavioural activation therapy via both a mobile phone and a personal website. The system motivates the client to continue with the treatment and helps him/her through the different procedures of the treatment. The architecture of the system follows a generic ambient agent architecture. A first pilot study of the system indicates that it is technically feasible and perceived as useful.

1 INTRODUCTION

Dozens of well-designed studies and meta-analyses have shown that psychological interventions are effective in the treatment of depressive disorders in adults. Psychological treatments that have been found to be effective include behavioural activation treatments (Cuijpers et al., 2007a), cognitive-behaviour therapy (Gloaguen et al., 1998), interpersonal psychotherapy (Churchill et al., 2001), problem-solving treatment (Cuijpers et al., 2007b), and psychodynamic therapy (Leichsenring, 2001).

There is also a growing number of studies showing that self-administered psychotherapies are effective in the treatment of depression. Self-administered psychotherapy can be defined as a psychological treatment, in which the patient takes home a standardized psychological treatment and works it through more or less independently. In a standardized psychological treatment, a patient can read step-by-step what he can do to apply a generally accepted psychological treatment to himself. The standardized psychological treatment is often written down in book form, but is more and more applied through other media, such as a personal computer and the Internet.

Although self-administered treatments are mainly conducted by clients themselves, the role of supporting professionals remains important for successful application of the therapy (Spek et al., 2007a). There are several studies of self-administered and internet-based treatments showing that in the absence of support by a therapist, the drop-out rate is high and the effects of the treatment are much smaller (Christensen et al., 2004; 2006) or absent (Clarke et al., 2005). In general it is assumed, that professional support is needed to motivate the client to continue with the treatment and to help him/her through the different procedures of the treatment.

However, developing a psychological treatment that does not need a professional therapist, but still has some automated actor involved to interact frequently with the client, would hold a number of advantages. The treatment would be much cheaper and would become available for large groups of depressed people who do not receive any treatment currently (40% of depressed patients receive no treatment). Waiting lists, which are unfortunately very common in routine care, could be reduced considerably. The process of therapy is examined from a different angle and the effective ingredients

of psychotherapy could be examined in much more detail, because automated therapy could follow the patient and his/her behaviour in much more detail than is currently possible.

The current project addresses the development of an automated interactive psychotherapy for depression: BAS (behavioural activation scheduling). The core of the project is a media based intervention in which the patient works on a systematic internet intervention, in which he or she plans her daily activity (based on the principles of behavioural activation therapy, see below) and receives a mobile phone with unlimited internet access. This mobile phone will help the patient during the day to work through the behavioural activation treatment. This daily support (through the mobile phone) is fully automated.

In this paper, the design of the BAS automated psychotherapeutic system is presented and first experiences within a pilot study are reported. Section 2 describes the psychological intervention *activity scheduling* that is the basis of the current project. Based on the principles of intelligent ambient agents, an overview of the system architecture is given in Section 3. The conducted pilot study and the results are described in Section 4. Finally, the paper is concluded with a discussion.

2 ACTIVITY SCHEDULING

Activity scheduling (AS, also called behavioural activation) is an intervention for clinical depression based on a theory by Lewinsohn, Youngren & Grosscop (1979) who say that a low rate of behaviour (often caused by inadequate social skills) is the essence of a depression and the cause of all other symptoms. Part of his theory is the hypothesis that there is a causal relationship between lack of positive reinforcement from the environment and the depression. A depression can be treated by increasing the positive reinforcement through increasing the quantity and quality of (social) activities. Many studies have shown that this type of intervention works just as well as or even better than other popular treatments, such as cognitive (behavior) therapy (CT or CBT) and antidepressant medication (Dimidjian et al, 2006; Jacobson et al, 1996; Iqbal & Bassett, 2008). Recently, it is shown that interventions offered via the internet are very effective (Christensen et al, 2004; Proudfoot, 2004, Andersson et al, 2005, Spek et al, 2007b).

There are two stages in AS treatment: the first stage is observing that pleasant activities and a good mood come together by writing down all pleasant activities and mood level. Usually, the more pleasant activities have been performed, the better the mood has been. The second stage is changing the activity schedule so that the patient participates in more pleasant activities with the goal of increasing the mood level. By doing more pleasant activities in stage 2, the mood increases on a short term, and by learning that pleasant activities influence mood level positively, patients are more capable of dealing with future situations.

For the BAS intervention, a five-step plan is used. In the first step, people start rating their mood via a mobile phone or via a website. In the second step, participants start registering their current pleasant activities via an agenda on the website and rate the activities. In this step, a list is build with activities that the person experiences as pleasant. The second phase starts with step three, during which the patient starts with actively planning more pleasant activities. In addition, a goal can be set with the desired mood level at the end of the intervention. During step four, the user is encouraged to keep doing more pleasant activities in order to improve the mood further. The same assignments can be done as in step three: the goal can be adjusted and a new weekly schedule of pleasant activities can be made. Automated weekly feedback informs the user about the progress and about how to improve the agenda so that a steady increase in mood level can be achieved. During the final fifth step the patient keeps scheduling pleasant activities. In addition, a plan for the future can be made to help prevent relapse and reoccurrence of depression.

3 AGENT MODEL

Automated psychotherapy via website and mobile phone can be seen as an instance of Ambient Intelligence applications, where software has knowledge about human behaviours and states, and (re)acts on these accordingly (Aarts *et. al.,* 2003). For this class of applications an agent-based generic model has been developed (Bosse *et. al.,* 2009). This model can be instantiated by case-specific knowledge to obtain a specific model in the form of executable specifications that can be used for simulation and analysis. In this section, the automated psychotherapeutic intervention will be described using this generic framework.

3.1 Generic Framework for Human Ambience applications

For the global structure of the generic model for human ambient applications, first a distinction is made between those components that are the *subject* of the system (e.g., a patient to be taken care of), and those that are *ambient*, supporting components. Moreover, from an agent-based perspective, a distinction is made between active, *agent* components (human or artificial), and passive, *world* components (e.g., part of the physical world or a database).

Second, interactions between model elements are defined. An interaction between two agents may be *communication* or *bodily interaction*, for example, fighting. An interaction between an agent and a world component can be either *observation* or *action* performance. An action is generated by an agent, and transfers to a world component to have its effect there. An observation has two directions: the *observation focus* is generated by an agent and transfers to a world component (providing access to a certain aspect of the world), and the provision of the *observation result* is generated by the world component and transfers to the agent. Combinations of interactions are possible, such as performing an action and observing the effect of the action afterwards.

Finally, ambient agents are assumed to maintain knowledge about certain aspects of human functioning in the form of internally represented dynamic models, and information about the current state and history of the world and other agents. Based on this knowledge they are able to have a more in-depth understanding of the human processes, and can behave accordingly.

3.2 Agent System Overview

Figure 1 gives an overview of the different components in the ambient agent model. In the remainder of this section, the components and their specific interactions are described. In Section 3.3, the internal knowledge of the specific agents is given.

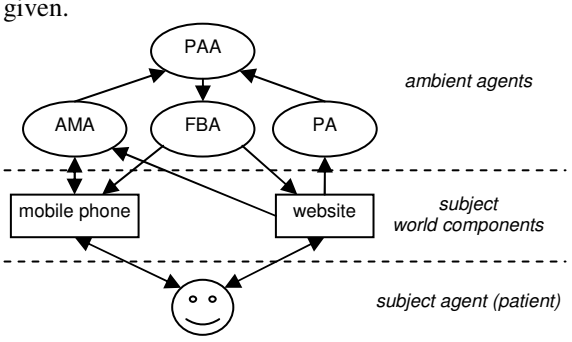

Figure 1. Components in the ambient agent model.

3.2.1 Subject components

Subject agents: participant suffering from a depression.
Subject world components: mobile phone of the participant, computer of the participant with a dedicated website.

Subject interactions

Observations and actions by subject agents: Participant inputs information requested for therapy into either the mobile phone or the website via a computer. This includes:

Mobile phone actions by participant:
- Mood rating (number between 1 and 10)
- Activity rating (number between 1 and 10)
- Request advice

Mobile phone observations by participant:
- Activity schedule
- Tips

Web site actions:
- Planning activities
- Planning rewards
- Adding possible activities to a list
- Setting goals for the week

Web site observations
- Information about therapy, explanation
- Outcome of all actions performed (see above)

3.2.2 Ambient components

Ambient agents: activity monitoring agent (AMA), patient assessment agent (PAA), feedback agent (FBA), activity planning agent (APA)

Ambient interactions

Communication between ambient agents: the AMA sends the information about the monitoring and rating of activities to the PAA, APA sends schedule and information to the PAA, PAA sends feedback to the FBA.

Interactions between subject and ambient

Reminders
- Planned activities (AMA – mobile phone)
- Rating of mood (AMA – mobile phone)
- Rating of performed activities (AMA – mobile phone)

Reporting about ratings and activities
- Rating of mood (website / mobile phone – AMA)
- Rating of performed activities (website / mobile phone – AMA)
- Planned activities (website – APA)

Feedback

- Motivational remarks (FBA – website / mobile phone)
- Weekly feedback (FBA – website / mobile phone)
    - Plots of mood versus number of activities and rating of activities
    - Remarks about mood during week
    - Remarks about activities during week
    - Remarks about combination of mood and activities
    - Feedback on targets set for week

3.3 Individual Agents

3.3.1 AMA: Activity Monitoring Agent

This agent is responsible for monitoring which activities have been performed by the patient and what the mood of the patient was at different moments (specifically after doing activities).

Maintenance of Agent Information. Maintain the ratings of the mood and the list of performed activities. Maintain preferences concerning how frequent reminders should be sent and the reminders that have already been sent.

Maintenance of World Information. None.

Agent Specific Task. Based upon the information present: derive reminders. There are two types of reminders, namely (1) reminding the participant of the planned activities, and (2) reminding the participant to rate the activity and the mood.

Reminders for planned activities
The agent sends out such a reminder in case:

1. The participant requested a reminder (by indicated it in the activity schedule).
2. In case of a pattern of missed activities:
    a. If the participant has missed a specific activity 2 times in a row, or 2 out of 3 times. The reminder is then sent half an hour before the activity is planned.
    b. If the participant has missed two activities in general on a particular part of the day (e.g. never performs activities in the morning). Again the reminder is sent half an hour before the activity has been planned.

Reminders for mood and activity rating
Next to the monitoring of activities being followed, reminders of the rating of these activities are also sent. This is done when during the past three days less than 50% of the planned activities have been rated. Reminders for mood rating are sent based upon the mood rating frequency setting shown in the following table.

Table 1. Reminder frequency for mood rating.

Mood rating setting	*First reminder*	*Second reminder (email)*	*Contact care taker*
3 times per day	After four misses, afternoon of day 2	After a full day without response upon first reminder	After a full day without response on the second reminder
1 time per day	After one miss, evening of day 2	After a full day without response upon first reminder	After a full day without response on the second reminder
1 time per 2 days	After one miss, end of day 3	After a full day without response upon first reminder	After a full day without response on the second reminder

World Interaction Management. Process the information about performed activities, ratings and mood inserted into the mobile phone or via the website. Send reminders to the mobile phone (i.e. the patient).

Agent Interaction Management. Communicate the fact that ratings have been given to the PAA.

3.3.2 APA: Activity Planning Agent

The APA keeps track of the planned activities and reports this to the PAA.

Maintenance of Agent Information. Maintain information about the activities that are planned by the patient.

Maintenance of World Information. None.

Agent Specific Task. Based upon the information provided by the user and the options in the phase of the therapy: maintain a schedule of activities.

World Interaction Management. Process the information inserted into the website.

Agent Interaction Management. Communicate the schedule on request to the PAA.

3.3.3 FBA: FeedBack Agent

The role of this agent is to communicate information via either the mobile phone or the website based on the analyses of the PAA. This can be *weekly feedback*, daily *motivational remarks* or general conclusions about the progress of the therapy derived by the PAA.

Maintenance of Agent Information. Maintain preferences with respect to the media that is preferred (and suited) for specific type of feedback, and keep track of the feedback that has been sent.

Maintenance of World Information. None.

Agent Specific Task. Triggered by the PAA: generate weekly feedback, select motivational messages, or forward analysis from PAA to the patient.

Weekly feedback
The weekly feedback is meant to create awareness of the participant that there is a relationship between mood and the activities being performed. First of all, in week one and two of the therapy overviews are given of the number of activities in relation with the mood (see Figure 2) as well as the relation between the rating of the activities and mood (see Figure 3).

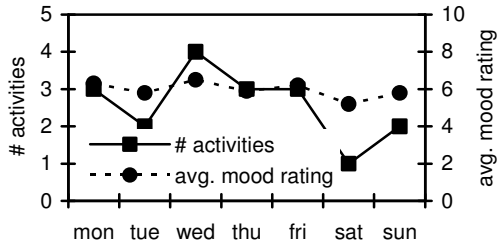

Figure 2. Number of activities and mood rating per day.

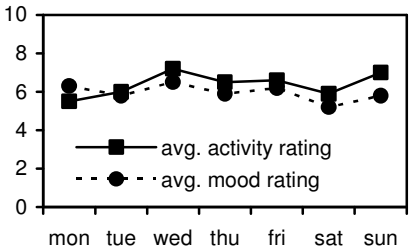

Figure 3. Average activity rating and mood rating per day.

Motivational remarks
Furthermore, also motivational remarks are sent; this is triggered by the PAA when it receives information from the AMA that the patient has rated either his/her mood or activities. These remarks are sent based upon the circumstances:
Maximum of one message per day

1. Communicate the highest mood of the past three days if this is higher than '6', also communicate the activities during that particular day: *"Your highest mood during the last three days was on X: a Y! That day you performed the following activities: [list of activities and rating]*.
2. Communicate an encouraging message in case the rating for mood just inputted was '6': *"You rated your mood at X now, how nice!"*. In case it was '7': *"You rated your mood at X now, that's really nice!"*. Or in case of an '8' or higher: *"You rated your mood X, that's excellent!"*.
3. Communicate the percentage of tasks that have been performed, given that during the last 3 days at least 2 activities have been performed. In case more that 70% of the activities have been performed: *"The last three days your adherence to the planning was very good, you performed X activities, which is Y% of the scheduled activities"*. In case less than 50% has been performed: *"You did not adhere that well to the planning during the last 3 days, you performed X% of the activities, which totals to Y activities. Try to adhere to your agenda somewhat better"*. In all other cases: *"During the last 3 days you performed X% of your planned activities"*.
4. If the average mood of day 4 of the week is at most 0.5 of the goal mood (in case applicable in the stage the participant is in): *"Your average mood this week is X, you've almost achieved your goal. Keep this up till the end of the week! Thereafter you can reward yourself with Y"*. Note that the last part of the remark is only communicated in case specific rewards have been specified.

In case none of the above hold or are sent on the current day:

5. A tip (from a list of tips from experts).

World Interaction Management. Sends messages to the website or the mobile phone.

Agent Interaction Management. None.

3.3.4 PAA: Patient Assessment Agent

The task of the PAA is to assess the status of the patient and to guide which feedback is given at what moment to the patient via the FBA.

Maintenance of Agent Information. Maintain information about the history of the patient, in terms of prior mood ratings, activities performed, and ratings for the activities. Maintain information about the phase of the therapy.

Maintenance of World Information. Keep track of the time.

Agent Specific Task. Based upon the information present: derive conclusions about the performed activities and ratings in the past week. Decide on the type of feedback that has to be given to the patient.

Conclusions about past week
Based on information about the reported mood of the patient and the performed activities, the following abstracted remarks can be generated and sent to the FBA:

- Mood: *"Your average mood during this week was A, on day C your mood was lowest, namely B"*.
- Activities: *"You performed E fun activities this week, on average this is D fun activities per day"*.
- Mood in combination with activities: *"Your low mood on day C corresponds with few pleasant activities, namely F. This shows that doing less fun activities can decrease your mood level"*.

After the two week period more elaborate conclusion are generated. For the sake of brevity, these rules are not shown. They can however be found in Appendix A (in Dutch, http://human-ambience.few.vu.nl/docs/HealthInf10-appA.pdf).

World Interaction Management. None.

Agent Interaction Management. Send messages to be communicated to the patient to the FBA.

4 PILOT STUDY

A pilot study with the system described above has been performed, which is described in the next section. The pilot resulted in a number of conclusions, which are presented in Section 4.2.

4.1 Participants and Method

A total of nine participants joined the experiment, all students at the VU University Amsterdam, age ranging between 18 and 24 (average 21.2). They followed the intervention during three weeks after a start-up meeting. During that meeting, they received a Sony Ericsson M600i mobile phone, a link to the website and a brief explanation of the intervention. All participants were instructed to follow all assignments and to test the system by for instance entering a lot of activities in the agenda or not logging in for a while to see how the system reacts. In addition, they were asked to describe any technical errors in detail. After every week the participants provided feedback about the intervention face-to-face or via telephone. These interviews were semi-structured: a list was used with general questions that the participants received in advance. The questions were structured in five groups: look and feel, technical, textual, reminders and weekly feedback. During the final meeting, the participants handed over their phones and received €100 participation fee. At the end of the three weeks, an online questionnaire was filled in.

4.2 Results

The results of the weekly feedback sessions and of the evaluation questionnaire are shown in the following two sections.

4.2.1 Weekly Feedback Sessions

There were three feedback sessions per participant at the end of week one, two and three of the intervention. The results are shown per subsection of the questionnaire summarized over the three weeks.

Look and feel. Most comments on the look and feel of both the website and the application on the phone were made after the first week. The website was judged as clean and simple. Negative comments were about broken and illogically placed links, the layout of the menu and the font size of some of the forms. Four of the nine participants complained about the simple agenda feature: they would have liked to see more functionality such as a week overview, setting an end time for activities and a warning message when two activities are planned at the same time.

Remarks about the mobile phone application were about functionalities people missed, such as changing the comments about a mood rating after saving the rating and adding or changing activities in the agenda. Some participants had difficulties interacting with the mobile phone itself. The Sony Ericsson M600i has input possibilities via the touch screen and a QWERTY keyboard with quite small keys.

Technical. The participants did not find many technical problems with both applications. As mentioned above, there were some broken links on the website. There were also some problems with functionalities: the option 'I did not do this activity' was missing from the activity-rating page on the website and it was possible to give a mood rating of days in the future. Two participants received an error message on their phone after saving a mood or activity rating; this had to do with the motivational remark that was shown afterwards.

Textual. In the first feedback session, some spelling and grammar mistakes were shown. Most of the texts on the website were found very clear. However, more explanation about the mobile phone

application and about when reminders could be expected was required according to most participants. In addition, no information about the transition between steps was provided and some participants were surprised when they automatically started with the next step.

Reminders. When asked about the usefulness of the reminders for rating mood and activities, all nine participants answered positively. However, they did not agree about the frequency. As shown in Table 1, the frequency of reminders is determined by the mood rating setting. The more often someone plans to rate their mood, the sooner a reminder is sent when mood has not been rated. Some participants found that the first reminder came too soon, others found that it came not soon enough.

Reminders before a planned activity also showed a pattern, although none of the participants noticed it. They all said these reminders seemed random, but were useful despite the randomness.

Weekly feedback. Eight out of nine participants said that they enjoyed reading the weekly feedback and that the content matched their own experience during that week. A few of the automatically generated sentences needed more explanation, some spelling errors were found and the numbers shown in the feedback were not rounded enough (e.g. 71.11111% of the planned activities were rated). In addition, the participants needed to be directed to the weekly feedback, since no information was provided on the website about where and when to find it. Overall, only minor negative points were made about the weekly feedback and most participants were very positive.

4.2.2 Evaluation Questionnaire

All participants filled out an online evaluation questionnaire after the three-week course. The first questions were about which steps the participants read and executed. As explained above, not all participants arrived at the final step and that was the only reason why some did not read or execute step 5. The results of the questions about how much the course was enjoyed are shown in table 2.

Table 2. Results of the evaluation, the scale is from 1 (totally disagree) to 5 (totally agree).

Question	Mean answer
the information was new	2.7
I enjoyed viewing the website	3.8
I enjoyed working with the phone	3.8
the course was interesting	4.3

To the question 'how useful was the course for you' only one participant answered *no*, six answered *a little* and two answered *a lot*. A surprising result since none of the participants was diagnosed with depression. As an explanation, most wrote that they became more aware of the amount of pleasant activities they normally do and learned to make time for more fun activities during stressful periods. The reminders that the participants received on their phone were judged as very useful. Only the frequency was judged by some as too often and by others as not often enough. In general, the participants found using the mobile phone for mood rating a nice functionality, mostly because a mobile phone made it easier to rate mood several times a day compared with using a computer.

The participants were also asked to score the overall intervention on a scale of 1 to 10: the mean score was 7.1. When asked for tips to improve the system, the participants answered 'more and clearer interaction between mobile phone program and website', 'more functionalities via the mobile phone such as editing the agenda', and 'using a different mobile phone'. The last comment is about the mobile phone itself and not about the intervention, for which people have different personal preferences.

5 DISCUSSION

In this paper, an unguided intervention for depression via mobile phone and website is presented. The intervention is based on the Activity Scheduling therapy, which has proven to be effective against depression. The automated intervention is an Ambient Intelligent System, for which a generic agent framework is used. A first pilot study was conducted with nine participants without a depression to test the system technically and on acceptability.

Based on the results of the pilot study, some changes have been made in a new version of the BAS system. The few technical issues are solved and some texts were revised. Based upon the critic of the participants on the weekly feedback and the unexpected evolving to the next step, three new general messages are added. They are generated in the PAA and sent to the FBA, following the table below.

Table 3. General messages.

Situation	*Message*
Moved a step in therapy	Congratulations, you've moved on to step X! You can reward yourself with Y. Log on to the website to read the description of the next step.
New weekly feedback available	There is new weekly feedback available on the website.
1 day before the weekly feedback, and less than 50% of the activities have been rated.	A new weekly update will be available tomorrow, do not forget to rate your mood and the activities.

Furthermore, the agenda functionality on the website is extended with a weekly overview, end times of appointments and a warning when two activities are planned at the same time. The rating system on the mobile phone is changed slightly, so that people can edit the comment field after saving the rating. The final adjustment is made in the reminder system: besides the mood rating setting (see Table 1), there is also a reminder frequency setting with the options low, medium and high. A combination of the two settings determines when a reminder is sent. When the reminder frequency is set to high, the participant receives a reminder after missing two rating moments, when set to medium, a reminder is sent after three missed rating moments and when set to low after four missed rating moments.

The pilot study indicates that advanced support via a website and mobile phone during activity scheduling intervention is technically feasible and perceived as useful. In the near future, a second pilot study will be conducted with between five and ten participants who suffer from a depression. The participants will be questioned in the same manner as described in this paper. After processing the results, an efficacy study will be performed with around 100 participants with a depression to determine whether their depression is lessened by the BAS intervention system.

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